IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

## REQUEST FORM FOR FILING CONTINUING APPLICATION UNDER 37 C.F.R. § 1.53(b)

Attorney Docket Number: **47382.000110**
Anticipated Classification Of This Application:
Class _________ Subclass _____________

Prior Application: 09/520,165 (47382.000101)
Examiner: Unassigned
Art Unit: 2736

**Assistant Commissioner for Patents**
**Washington, D.C. 20231**

Sir:

This is a request for filing a [X] *continuation* [ ] divisional application under 37 C.F.R. § 1.53(b) of prior Application Serial No.**09/520,165**, filed on **March 7, 2000**, which is a continuation of **09/398,198**, filed on **September 17, 1999**, which claims priority to provisional application Serial No. **60/100,731**, *filed on* **September 17, 1998**, which is entitled **REMOTE EMISSIONS SENSING SYSTEM AND METHOD WITH A COMPOSITE BEAM OF IR AND UV RADIATION THAT IS NOT SPLIT FOR DETECTION** by the following named inventors: **John DIDOMENICO and Craig S. RENDAHL**.

1. **[X]** Enclosed is a true copy of the prior complete application as originally filed.
2. [ ] Preliminary Amendment is enclosed.
3. [ ] Cancel in this application original claims _________ of the prior application before calculating the filing fee. At least one original independent claim is retained complete the prior application introduced new matter therein.
4. **[X]** The filing fee is calculated on the basis of the claims existing in the prior application as mentioned at 1, 2 and 3 above.

| FOR | NUMBER FILED | NUMBER EXTRA | RATE | CALCULATIONS |
|---|---|---|---|---|
| TOTAL CLAIMS | 7 | 0 | x $ 18.00 = | $ 0.00 |
| INDEPENDENT CLAIMS | 2 | 0 | x $ 80.00 = | $ 0.00 |
| MULTIPLE DEPENDENT CLAIM(S) (if applicable) | | | x $ | $ 0.00 |
| | | | BASIC FEE | + $ 710.00 |
| | | | TOTAL OF ABOVE CALCULATIONS= | + $ 710.00 |
| REDUCTION BY ½ FOR FILING BY SMALL ENTITY (Note 37 C.F.R. 1.9, 1.27, 1.28). IF APPLICABLE, VERIFIED STATEMENT MUST BE ATTACHED. | | | | - $ 710.00 |
| | | | TOTAL = | $ 710.00 |

5. **[X]** The Commissioner is hereby authorized to charge fees under 37 C.F.R. § 1.16 and § 1.17 which may be required, or credit any overpayment to Deposit Account No. 50-0206.
6. **[X]** A check in the amount of **$710.00** is enclosed to cover the fee for filing this continuation application. In the event any variance exists between the amount enclosed and the Patent Office charges, please credit or charge any different to Deposit Account No. 50-0206.

7. **[X]** Amend the specification by inserting before the first line the sentence:
This application is a continuation of Application Serial No.**09/520,165**, filed on **March 7, 2000**, which is a continuation of Application Serial No. **09/398,198**, filed **September 17, 1999**, which claims priority to Provisional Application Serial No. **60/100,731** filed **September 17, 1998**.

8. [ ] A verified statement to establish small entity status under 37 C.F.R. §§ 1.9 and 1.27
[ ] is enclosed.
[ ] was filed in prior application Serial No. ______ and such status is still proper and desired (37 C.F.R. § 1.28(a)).

9. [ ] Priority of foreign Application Nos. ________, filed on _______, is claimed under 35 U.S.C. § 119.
[ ] A certified copy of each was filed in prior Application Serial No. _____, filed _____.

10. [ ] New formal drawings are enclosed.

11. [ ] The prior application is assigned of record to ________________________.

12. [ ] The power of attorney in the prior application is to Hunton & Williams.
a. [ ] The power of attorney appears in the original papers in the prior application.
b. [ ] Since the power does not appear in the original papers, a copy of the power in the prior application is enclosed.
c. [ ] Recognize as Associate Attorneys:
d. [ ] Please remove as power of attorney:

13. **[X]** Also enclosed: An INFORMATION DISCLOSURE STATEMENT. Attached are Forms PTO-1449 listing all of the documents cited by Applicants and the PTO in the parent application(s) relied upon 35 U.S.C. 120. Per Rule 98(d) copies of those documents are not required now. Please consider these documents and advise that they have been considered in this new application by returning a copy of the enclosed Forms PTO-1449 with the Examiner's initials in the left column per M.P.E.P. 609.

14. **[X]** Address all future communications to:

James G. Gatto, Esq.
Hunton & Williams
1900 K Street, N.W.
Washington, D.C. 20006-1109

The undersigned further declares that all statements made herein of his own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that willful false statements may jeopardize the validity of the applications or any patent issuing thereon.

Raphael A Vale

Dated: November 3, 2000

By: RAPHAEL A. VALENCIA 43,216 for
Christopher J. Cuneo
Registration No. 42,450

LAW OFFICES
HUNTON & WILLIAMS
1900 K STREET, N.W.
WASHINGTON, D.C. 20006-1109
(202) 955-1500

# REMOTE EMISSIONS SENSING SYSTEM AND METHOD WITH A COMPOSITE BEAM OF IR AND UV RADIATION THAT IS NOT SPLIT FOR DETECTION

## FIELD OF THE INVENTION

The invention relates to a remote emissions sensing system and method that uses a composite detector beam of infrared (IR) and ultraviolet (UV) radiation. The detector beam is used to perform spectroscopic measurements upon an emissions source and the beam is not split during detection.

## BACKGROUND OF THE INVENTION

Remote emissions sensing systems generally are known. One such system comprises a source of electromagnetic radiation arranged to pass a beam of radiation through the exhaust plume of a motor vehicle as the motor vehicle passes by the system, and one or more detectors arranged to receive the radiation after it passes through the exhaust plume of the vehicle. Filters may be associated with one or more detectors to detect the intensity of electromagnetic radiation at a particular wavelength or range of wavelengths. The wavelengths may be selected to correspond to wavelengths absorbed by molecular species of interest in an exhaust plume (*e.g.*, HC, CO, $CO_2$, $NO_x$, or other molecular species). The detector's output voltage represents the intensity of the electromagnetic radiation measured by that detector. The voltages are input to a processor. The processor calculates the difference between the known intensity of the electromagnetic radiation source and the intensity detected by the detectors to determine the amount of absorption by particular molecular species (based on predetermined wavelengths associated with that species). Based on the measured absorption(s), the concentration of one or more molecular species in the emissions may be determined in a known manner. Such systems generally take a plurality of measurements (*e.g.*, 50) over a predetermined period of time (*e.g.*, 0.5 seconds). These

measurements are then plotted and analyzed to determine concentrations of target emissions. When using a plurality of measurements, however, if one or more measurements are inaccurate, concentration calculations may be erroneous or invalid. For various reasons, inaccuracies can occur when remotely sensing emissions.

Some remote emission sensing systems do not have the capability to detect nitrous oxides ($NO_x$). Other systems detect $NO_x$ with a UV beam and other molecular species with an IR beam. In one such system, the UV and IR beams are split into separate beams at the detector module. One reason for this splitting is that unequal detection times have been believed necessary for the UV and IR portions of the beam. For example, a longer UV detection time has been believed necessary to ensure adequate $NO_x$ detector signal. One problem with such a system is that unequal detection times require additional system elements which increase the difficulty in aligning the system. Other drawbacks exist.

SUMMARY OF THE INVENTION

One object of the invention is to overcome these and other drawbacks of existing systems.

Another object of the invention is to provide a remote emissions sensing system and method with a composite beam of IR and UV radiation that detects $NO_x$ and at least one other molecular species, where the alignment of the system is relatively easier than the alignment of a system wherein the UV and IR beams are split for detection.

Another object of the invention is to provide a remote emissions sensing system and method with a composite beam of IR and UV radiation that is not split for detection.

Another object of the invention is to provide a remote emissions sensing system and method with a composite beam of IR and UV radiation that detects $NO_x$ and at least one other molecular species, where the composite beam is alternately incident upon a $NO_x$ detector and a detector for the at least one other molecular species.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic block diagram that depicts the overall remote emissions sensing system in accordance with one embodiment of the present invention: and

FIG. 2 is a schematic diagram of the detector optics module used in the remote sensing system according to one embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 depicts one embodiment of a remote sensing exhaust emission detector system in accordance with the present invention. According to this embodiment, the exhaust emission detector system includes: source optics module 1, detector optics module 2, transfer optics module 3, and processor 4. According to one embodiment of the invention, the processor 4 is operatively connected to both source optics module 1 and detector optics module 2.

Source optics module 1 may include one or more sources of electromagnetic radiation which generates and emits a radiation beam 5 which may be collimated. According to one embodiment of the invention, the beam 5 emitted at source optics module 1 may include at least infrared (IR) and ultraviolet (UV) radiation. Other beam types are possible.

As shown in FIG. 1, beam 5 may be directed across a roadway 6 along a predetermined path where it may impinge upon transfer optics module 3 located opposite to source optics module 1. Transfer module 3 directs beam 5 back across roadway 6 to detector optics module 2. Other system configurations may be used. For example, according to one embodiment of the invention, transfer optics module 3 is not used at all. Instead, the source 1 and detector optics 2 may be disposed on opposite sides of the roadway such that detector optics module 2 receives beam 5 directly from source optics module 1. In any case, beam 5 is aligned to traverse a predetermined path that intersects at least a portion of an emissions source. In some embodiments, the emissions source may comprise an exhaust plume emitted

from a car or other motor vehicle 8 that travels on roadway 6. When vehicle 8 passes along roadway 6, beam 5 may be aligned to pass through the exhaust plume 7 of the vehicle.

FIG. 2 is an illustration of one embodiment of detector optics module 2. The detector optics module 2 may be used to guide beam 5 to appropriate detectors. Beam 5 may be guided by any suitable configuration of beam guides. For example, lenses, mirrors, fiber optics and other elements may be used to guide beam 5. According to one embodiment of the invention, the incoming beam 5 may initially be directed onto a primary focusing mirror 10, as shown in FIG. 2. The primary focusing mirror 10 may be pivotally and rotatably mounted on a support that is attached to the base (not shown) of the detector optics module 2. Further, the primary focusing mirror 10 may, for example, be pivoted at an angle such that the mirror 10 reflects the incoming beam 5 onto the mirrored surface 13 of a rotating mirror assembly 9. Other configurations of detector optics module 2 are also possible. For example, primary focusing mirror 10 may be eliminated if beam 5 is configured to be directly incident upon appropriate detectors. Alternatively, additional focusing mirrors and optics (*e.g.*, lenses, fiber optics, etc.) may be used in conjunction with primary focusing mirror 10.

Detector optics module 2 may also include additional elements to guide beam 5. For example, a rotating mirror 9 may be used. Rotating mirror assembly 9 may be located on top of a mount assembly (not shown) which may contain a drive motor to cause mirror assembly 9 to rotate. Such a mount assembly may be attached to the base of detector optics module. Although only one mirror is shown in FIG. 2, rotating mirror assembly 9 may also take the form of a multi-faceted structure, such as a dodecagon, where one or more sides of the structure may have a reflective surface.

As stated above, detector optics module 2 may be employed to guide beam 5 to appropriate detectors. Detector optics module 2 guides beam 5 in such a manner that beam 5 is not split during detection. Not splitting beam 5, among other things, simplifies the

alignment of the system components. In one embodiment, beam 5 is guided, without splitting, by using guide elements that sequentially direct beam 5 to predetermined detector locations. For example, a rotating mirror 9 may be employed to guide beam 5 without splitting. As shown in FIG. 2, rotating mirror assembly 9 spins such that when beam 5 is incident upon the mirrored surface of the rotating mirror assembly 9, the beam 5 is reflected from the rotating mirror assembly 9 onto one or more secondary, focusing mirrors 11a-11n, in a sequential manner. According to one embodiment of the invention, one or more of these secondary mirrors may be horizontally aligned with rotating mirror assembly 9 such that the secondary mirrors 11a-11n reflect and focus the beam 5 onto one or more detectors 12a-12n. Alternatively, other optical systems may be used to spatially separate the incident beam 5 for delivery to the various detectors 12a - 12n. For example, lenses, mirrors, optical fibers, etc., may be used to deliver the incident beam 5 to detectors 12a - 12n.

At least one of detectors 12a-12n is capable of detecting and measuring nitrous oxides ($NO_x$) without requiring beam 5 to be split. Preferably, the particular $NO_x$ detector used is capable of adequately detecting $NO_x$ concentrations (in a known manner) even when it is one of *n* detectors that are sequentially irradiated by beam 5 via rotating mirror 9. One example of a detector that is suitable for use in this embodiment is a real time photospectrometer. In one embodiment, a fiber optic light tube may be positioned at 12a and used to guide incident light into a photospectometer. Other detector schemes are possible.

As shown in FIG. 2, according to one embodiment of the invention, $NO_x$ detector 12a is operative to determine the amount of nitrous oxide in exhaust plume 7 by measuring the absorption of beam 5 at a wavelength corresponding to known absorption characteristics of $NO_x$. This detector may, for example, take the form of a photo-multiplier tube, photo-diode detector, a photospectrometer utilizing charge coupled devices, or another suitable radiation detector. Preferably, a detector with sensitivity to radiation in the 220 - 230 nm wavelength

range may be used to detect $NO_x$. Such an $NO_x$ detector may also operate in conjunction an optical UV bandpass filter, not shown.

The other detectors 12b-12n may also include a HC detector, a CO detector, a $CO_2$ detector, and a reference detector. Other detectors operable to measure various emission components of an exhaust plume may also be included. These detectors are preferably chosen with the capability to detect radiation in the appropriate range for each exhaust constituent.

Other embodiments and uses of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. The specification and examples should be considered exemplary only. The scope of the invention is to be determined from the claims appended hereto.

WHAT IS CLAIMED IS:

1. A system for remotely detecting emissions, the system comprising:

a radiation source, for generating a combined beam of ultraviolet and infrared radiation that propagates along a predetermined path;

a detector module, for receiving the beam of radiation and measuring at least one parameter indicative of the relative concentration of at least one emission constituent;

the detector module further comprising:

at least one detector to produce an output proportional to at least one characteristic of the received beam;

at least one beam director that directs the beam to the at least one detector without splitting the beam.

2. The system of claim 1, wherein the at least one beam director comprises a rotating mirror.

3. The system of claim 1, wherein the at least one emission constituent comprises nitrous oxides .

4. The system of claim 1, wherein the at least one beam director comprises a rotating mirror and the at least one detector comprises a real time photospectrometer.

5. A method for remotely detecting emissions, the method comprising:

generating a combined beam of ultraviolet and infrared radiation that propagates along a predetermined path, wherein the predetermined path is chosen to intersect at least a portion of an emissions plume;

receiving the beam at a detector module;

directing the beam to at least one radiation detector without splitting the beam; and,

measuring at least one parameter indicative of the relative concentration of at least one emission plume constituent.

6. The method of claim 5, wherein the step of directing the beam includes using a rotating mirror to direct the beam without splitting.

7. The method of claim 5, wherein step of directing the beam includes directing the beam to at least one detector that comprises a real time photospectrometer.

## ABSTRACT OF THE DISCLOSURE

A system and method for remote emissions detection that uses a composite beam of ultraviolet (UV) and infrared (IR) radiation. The composite beam is used to perform spectroscopic measurements on an emissions source plume. The composite beam is not split during detection, and may, among other things, be used to detect $NO_x$ in the emissions plume.